STRENGTH OF MATERIALS
Flexure in a Simple Beam

Objective

The goal of this exercise is to evaluate the stress distribution across a simple beam in pure bending. The position of the neutral axis and the stress distribution will be experimentally determined and compared to theoretical values.

Theory

The beam, or flexural member, is frequently encountered in structures and machines. Its elementary stress analysis constitutes an important area of mechanics of materials. A beam is a member subjected to loads applied transverse to the long dimension, causing the member to bend or flex.

Under elastic action, where Hooke's law applies, longitudinal strains in a beam are proportional to the distance from the neutral axis and stresses are proportional to strains. The flexure formula is given by:

$$\sigma = -\frac{My}{I} \qquad (1)$$

where y is the distance from the beam centroid, M is the bending moment and I is the second moment of the beam cross section about the neutral axis (NA).

This equation is used in beam analysis to obtain theoretical flexure stresses at any point on the cross-section. Strain gages can be placed on the beam to measure the longitudinal strain component which may be used to determine the experimental stress distribution by using Hooke's law. Since only one component of normal stress is non-zero the applicable Hooke's law relationship is:

$$\sigma = E\varepsilon \qquad (2)$$

Procedure:

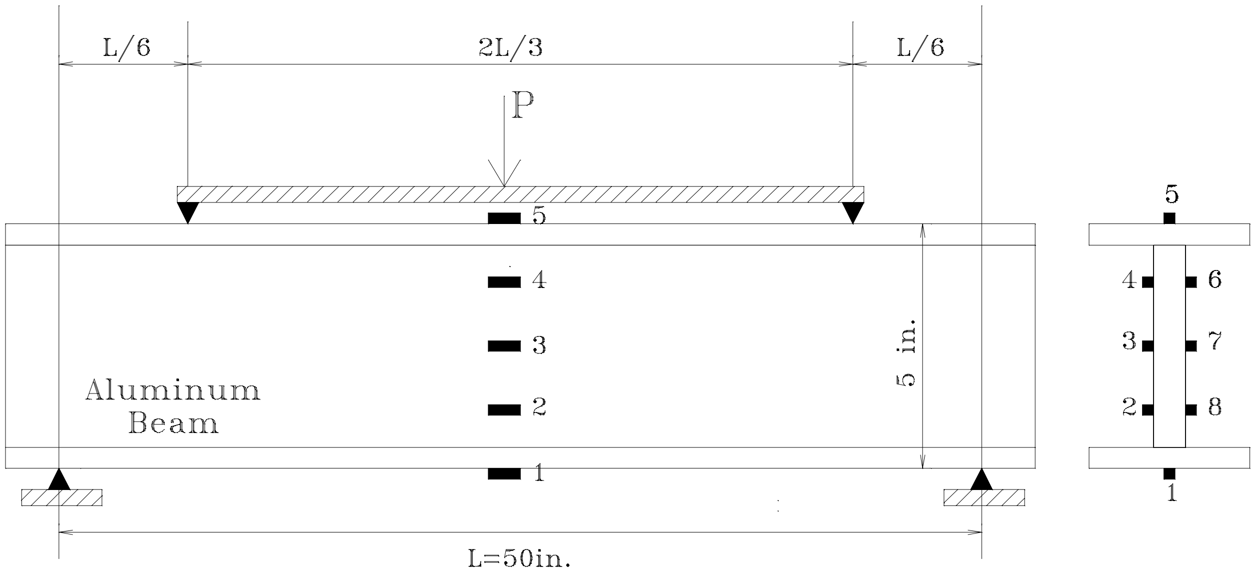
The test apparatus is shown in Figure 1. Loads are applied to the test beam in order to place the center of the beam in a state of pure bending. Strain gages mounted at the midpoint of the beam are used to obtain the strain at each gage location.

Load the beam with 3000, 6000, and 9000 lb. loads and record the strain at each gage for each load in Table 1. Average the strains at the gages mounted opposite to each other on the web to reduce error due to twisting of the beam. Calculate the "measured stress" from the average measured strain using Eq. 2 and record in Table 2. Using Eq. 1, calculate the theoretical stress expected at each gage for each load and record in Table 2.

Report

Use a spreadsheet/graphing program to plot a graph of the measured and calculated stresses (abscissa) versus distance from the centroidal axis (ordinate). Show the theoretical stress as a line plot only (do not show data points). Plot the experimental data as a scatter plot (show data points) and plot the line of best fit through your experimental data. Annotate your graph clearly. Use this best fit straight line to calculate the location of the experimental neutral axis with respect to the centroidal axis. Complete the laboratory report as described by your instructor. Include the items above as well as a comparison of theoretical and measured stress distributions and centroidal axis location.

revised by M. Koul 1/02



$I = 12.26\ in^4$	$E = 10.4x10^6$ psi

Figure 1 – Schematic of test apparatus with strain gages spaced equally at 1.25 in. intervals.

Table 1 - Raw Data

	Strain at Gage No. (µ in/in)							
Load (P) (lbs)	Gage 1	Gage 2	Gage 3	Gage 4	Gage 5	Gage 6	Gage 7	Gage 8
3000								
6000								
9000								

Table 2 - Computed Data:

	Load (P) (lbs)	Theoretical Stress (psi)	"Measured" Stress (psi)	% Difference
Gage Position 1	3000			
	6000			
	9000			
Gage Position 2	3000			
	6000			
	9000			
Gage Position 3	3000			N/A
	6000			N/A
	9000			N/A
Gage Position 4	3000			
	6000			
	9000			
Gage Position 5	3000			
	6000			
	9000			